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Europäisches Patent Nr.**European Patent No.****Brevet européen n°****1377990****Patentinhaber****Proprietor of the Patent****Titulaire du brevet**

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(54) THIN FILM RESISTOR HAVING TANTALUM PENTOXIDE MOISTURE BARRIER
DÜNNSCHICHTWIDERSTAND MIT TANTALPENTOXID FEUCHTIGKEITSBARRIERE
RESISTANCE A COUCHE MINCE COMPRENANT UNE BARRIERE DE PENTOXYDE DE TANTALE
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Description**BACKGROUND OF THE INVENTION**

[0001] This invention relates to a method for a thin film resistor having a tantalum pentoxide moisture barrier.

[0002] Current film resistors and the associated processes of making such resistors have had problems with the ability to create or use an effective moisture barrier. A moisture barrier is that layer that is deposited on the surface of the resistor in order to prevent moisture in the form of condensation or vapor from degrading the resistive film element. Screen-printed material has been used as a moisture barrier and this has been shown to reduce the failure rate of the resistor due to moisture. However, problems remain.

[0003] Tantalum pentoxide has been used in the semiconductor industry as an insulator and to improve recording performance of cobalt alloy media on glass-ceramic disks. Tantalum pentoxide has been used within the resistor industry to improve resistive elements integrated with spark plugs and to form a graze resistor. It is also associated with a tantalum nitride resistive system that prevents moisture failure. It is recognized that tantalum nitride resistors have a naturally occurring layer of tantalum pentoxide, the result of an oxidation process. Further, tantalum nitride resistors and tantalum nitride capacitors are known for their resistance to moisture.

[0004] The document JP 01 291 401 A describes a method of manufacturing a thin film resistor by depositing on a substrate a Ta_2N film, a Ta film which is then oxidized to form a tantalum pentoxide film.

[0005] Tantalum pentoxide has also been used in thermal heads where a glazed layer is placed on a substrate and a resistor layer is placed on the glazed layer. Japanese publication JP 01 133 755 A discloses such a thermal head with a glazed layer insulating the resistor layer and a protective film such as tantalum pentoxide sputtered onto the resistive layer. A thermal head has a different structure and purpose than a chip resistor. In addition, the chip resistor of the present invention would not include such a glaze layer.

[0006] Many thin film resistors, especially those of nickel-chromium alloys and other alloys containing nickel, chromium, and other metals are particularly susceptible to moisture conditions. These and other types of alloys have a failure mode of electrolytic corrosion that is capable of causing an electrical open under certain moisture conditions. In particular, under powered moisture conditions, electrolytic corrosion can occur and the resistor can fail. This makes the thin film resistor unsuitable for applications where moisture conditions may occur.

[0007] Thus, it is a primary object of the present invention to provide an improved method for a moisture barrier for film resistors.

[0008] Another object of the present invention is to

provide a method for a film resistor which is less susceptible to powered moisture testing.

[0009] Another object of the present invention is to provide a method for a moisture barrier capable of use with nickel-chromium, alloy thin film resistors.

[0010] Yet another object of the present invention is to provide a method for a moisture barrier for thin film resistors that does not require tantalum nitride.

[0011] Another object of the present invention is to provide a method for a moisture barrier for a thin film resistor replaces screen-printed moisture barriers.

[0012] Yet another object of the present invention is to provide a method for a moisture barrier for a thin film resistor that is compatible with normal manufacturing techniques and materials.

[0013] A further object of the present invention is to provide a method for a moisture barrier for a thin film resistor that can be used with nickel and chromium alloys.

[0014] Yet another object of the present invention is to provide a method for a moisture barrier for a thin film resistor that performs favorably under MIL-STD-202 method 103 testing.

[0015] A further object of the present invention is to provide a method for a moisture barrier for a thin film resistor that performs favorably under MIL-STD-202 method 106 testing.

[0016] Yet another object of the present invention is to a method to reduce or eliminate failures of thin film resistors due to electrolytic corrosion under powered moisture conditions.

[0017] Another object of the present invention is to provide a method for a moisture barrier that may be deposited through sputtering.

[0018] These and other objects, features, or advantages of the present invention will become apparent from the specification and claims.

BRIEF SUMMARY OF THE INVENTION

[0019] The present invention is a method for manufacturing a thin film chip resistors with a tantalum pentoxide moisture barrier. The invention provides for a tantalum pentoxide moisture barrier to be used in manufacturing a thin film resistor using otherwise standard manufacturing processes. The invention permits any number of metal films to be used as the resistive element. In particular, the invention permits nickel-chromium alloys to be used. The resistive metal film layer is overlaid with a moisture barrier of tantalum pentoxide. The tantalum pentoxide layer acts as a moisture barrier.

[0020] The tantalum pentoxide layer results in a thin film resistor that is resistive to moisture. In particular, the tantalum pentoxide moisture barrier allows the thin film resistor to be more resistant to electrolytic corrosion that causes an electrical open under certain moisture conditions. Thus the present invention provides for increased reliability in thin film resistors while using substantially

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conventional manufacturing techniques.

[0021] The method of the present invention is defined by the features of claim 1 and comprises depositing a metal film resistive layer directly overlaying and attaching to a thin film chip resistor substrate. The method further comprises attaching a chip resistor termination on each end of the metal film resistive layer. A moisture barrier consisting essentially of a layer of tantalum pentoxide film is deposited in an overlying relationship to the metal film resistive layer to reduce failures due to electrolytic corrosion under powered moisture conditions. The layer of tantalum pentoxide is not formed by a natural oxidation of the metal thin film resistive layer.

[0022] The resistor of the present invention is defined by the features of claims 8 or 13 and is formable according to the above described method. The resistor may include the tantalum pentoxide directly overlying and being attached to the resistive element or a passivation layer may be interposed between the moisture barrier and the film resistive layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Figure 1 is a side view of a prior art thin film resistor. Figure 2 is a side view of the thin film resistor having a tantalum pentoxide moisture barrier of the present invention.

Figure 3 is a flow chart showing a method of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] Figure 1 shows a prior art thin film resistor that may be manufactured with standard manufacturing processes. In Figure 1, a substrate 12 is used. The substrate 12 may be alumina or other substrate that may be used in thin film processes. Overlaid on the substrate is a layer of a metal film which serves as the resistive element for the thin film resistor. The metal film layer 14 may be any number of metal films but is often a nickel-chromium (nichrome) alloy or other alloy containing nickel and/or chromium. Nickel-chromium is one of the most common types of metal films used in thin film resistors. Overlaying the metal film layer 14 is passivation layer 16. The passivation layer 16 may be used to protect the thin film resistors electronic properties from deterioration from external contaminants. The passivation layer 16 may be a deposited scratch resistant material such as silicon nitride, silicon dioxide, or other materials such as may be known in the art. The thin film resistor 10 also includes termination 18. The termination 18 on the ends of the thin film resistor is used to electrically connect the thin film resistor.

[0025] The thin film resistor of the present invention is shown in Figure 2. The thin film resistor 20 is manufactured in a manner similar to the thin film resistor 10

of Figure 1. However, the thin film resistor 20 of Figure 2 also includes a moisture barrier layer 22. The moisture barrier layer 22 is a layer of tantalum pentoxide film. The tantalum pentoxide film may be sputtered onto the thin film resistor, the tantalum pentoxide layer overlaying the resistive metal film layer and optionally a passivation layer. The present invention contemplates that the passivation layer need not be used.

[0026] The addition of the tantalum pentoxide layer reduces failure due to electrolytic corrosion that causes an electrical open under certain moisture conditions. The thin film resistor 20 may use alumina as substrate 12, or other substrate material. The present invention is no way limited to the particular selection of the substrate, however, the present invention is capable of use in standard manufacturing processes. The passivation layer may be a layer of silicon nitride, silicon dioxide, or other material such as may be known in the art. The present invention contemplates that any number of metal films could be used, including metal films containing nickel, chromium, or both. Termination 18 for the thin film resistor 20 may be any type of termination typically used with thin film resistors. For example, termination 18 may include wrap around termination.

[0027] The thin film resistor of the present invention using a nickel-chromium metal film layer and having a tantalum pentoxide moisture barrier has been evaluated according to standard environmental test methods. The thin film resistor using a 1206-size wrap around termination chip resistor subjected to MIL-STD-202 method 103 tests. These tests are designed to evaluate the properties of materials used in electronic components as they are influenced by the absorption and desorption of moisture and moisture vapor. The test is an accelerated environmental test that uses high relative humidity and an elevated temperature. According to the test a temperature of 40°C and a relative humidity of between 90% and 95% was used. 10 Volts DC was applied to the resistors for 96 hours.

[0028] In the 96-hour test, the typical failure rate (without tantalum pentoxide) is from 0 to 4 parts per lot test open. Testing of the tantalum pentoxide moisture barrier thin film resistors where tantalum pentoxide was used as a moisture barrier indicates that there were no opens.

[0029] A second test was conducted with a second group of thin film resistors having the tantalum pentoxide moisture barrier. For the second test, the MIL-STD-202 method 106 was used for testing moisture resistance. This test differs from the previous test as it uses temperature cycling to provide alternate periods of condensation and drying. According to this test, the temperature range selected was between 65°C to -10°C with a relative humidity of between 90% and 100%. The test was conducted over a 240 hour period with 10 Volts DC applied.

[0030] In typical results for the 240 hour test (no tantalum pentoxide moisture barrier), approximately 90 percent of the resistors test fail. Test results for the 240

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hour test where tantalum pentoxide is used as a moisture barrier reveal that there were no failures.

[0031] The method of manufacturing the thin film resistor of the present invention is best shown in Figure 3. The thin film resistor of the present invention can be manufactured in a manner substantially consistent with thin film manufacturing processes. In step 30 a metal film is deposited through sputtering or other techniques. The metal film may be of an alloy containing copper, chromium, nichrome, or other metal such as may be known in the art. Optionally, in step 32, a passivation layer is deposited. The passivation layer be deposited through sputtering or through other techniques. The passivation layer is used to protect the thin film resistor from external contaminants. In step 34, a layer of tantalum pentoxide is deposited. The tantalum pentoxide layer may be deposited through sputtering or other techniques. The tantalum pentoxide layer serves as a moisture barrier to reduce electrolytic corrosion of the thin film resistor.

[0032] Thus, an apparatus and method for a thin film resistor having a tantalum pentoxide moisture barrier has been disclosed which solves problems and deficiencies in the art.

Claims

1. A method of manufacturing a thin film chip resistor with a moisture barrier comprising: depositing a metal film resistive layer directly overlaying and attaching to a thin film chip resistor substrate; attaching a chip resistor termination on each end of the metal film resistive layer; and depositing the moisture barrier consisting essentially of a layer of tantalum pentoxide film overlaying the metal film resistive layer to reduce failures due to electrolytic corrosion under powered moisture conditions, the layer of tantalum pentoxide not being formed by natural oxidation of the metal thin film resistive layer.
2. The method according to claim 1 and further comprising directly overlaying and attaching the moisture barrier to the film resistive layer.
3. The method according to claim 1 and further comprising directly overlaying and attaching a passivation layer to the metal film resistive layer and directly overlaying and attaching the moisture barrier to the passivation layer.
4. The method of claim 1 wherein the step of depositing a layer of tantalum pentoxide is sputtering tantalum pentoxide film.
5. The method of claim 1 wherein the metal film layer is an alloy containing nickel.

6. The method of claim 1 wherein the metal film layer is an alloy containing chromium.

7. The method of claim 1 wherein the metal film layer is a nickel-chromium alloy.

8. A thin film chip resistor (20) manufacturable by the method according to claim 1 comprising: a substrate (12); a metal thin film resistive layer (14) directly attached to the substrate, a chip resistor termination (18) attached on each end of the metal thin film resistive layer (14); and an outer moisture barrier (22) consisting essentially of tantalum pentoxide directly overlaying and attaching to the metal thin film resistive layer (14) for reducing failures due to electrolytic corrosion under powered moisture conditions, the tantalum pentoxide not being formed by natural oxidation of the metal thin film resistive layer.

9. The thin film chip resistor (20) of claim 8 wherein the metal thin film resistive layer (14) is an alloy containing nickel.

10. The thin film chip resistor (20) of claim 8 wherein the metal thin film resistive layer (14) is an alloy containing chromium.

11. The thin film chip resistor (20) of claim 8 wherein the metal thin film resistive layer (14) is a nickel-chromium alloy.

12. The thin film chip resistor (20) of claim 8 wherein the tantalum pentoxide is overlaid by sputtering.

13. A thin film chip resistor (20) manufacturable according to the method of claim 1 comprising: a resistive substrate (12); a metal thin film resistive layer (14) directly attached to the substrate (12), the metal thin film being non-tantalum; a chip resistor termination (18) attached on each end of the metal thin film resistive layer (14); a passivation layer (16) directly overlaying the metal thin film resistive layer (14); an outer moisture barrier (22) consisting of tantalum pentoxide directly overlaying the passivation layer (16) for reducing failures due to electrolytic corrosion under powered moisture conditions, the tantalum pentoxide layer not being formed naturally by oxidation.

Patentansprüche

1. Verfahren zur Herstellung eines Dünnschicht-Chipwiderstands mit einer Feuchtigkeitsbarriere, umfassend die folgenden Schritte: Auftragen einer ohmschen Metallfoliensicht direkt auf ein Dünnschicht-Chipwiderstandssubstrat und Befestigen

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- derselben daran; Anbringen eines Chipwiderstandsabschlusses an jedem Ende der ohmschen Metallfolienschiicht; und Auftragen der Feuchtigkeitsbarriere, die im Wesentlichen aus einer Tantalpentoxidfolienschiicht besteht, die auf der ohmschen Metallfolienschiicht liegt, um Ausfälle aufgrund von elektrolytischer Korrosion bei Stromzufuhr unter feuchten Bedingungen zu reduzieren, wobei die Tantalpentoxidschiicht nicht durch natürliche Oxidation der ohmschen dünnen Metallfolienschiicht entsteht.
2. Verfahren nach Anspruch 1, ferner umfassend das direkte Legen der Feuchtigkeitsbarriere auf die ohmsche Folienschicht und das Befestigen daran.
 3. Verfahren nach Anspruch 1, ferner umfassend das direkte Legen einer Passivierungsschiicht auf die ohmsche Metallfolienschiicht und das Befestigen daran und das direkte Auflegen der Feuchtigkeitsbarriere auf die Passivierungsschiicht und das Befestigen daran.
 4. Verfahren nach Anspruch 1, wobei der Schritt des Auftragens einer Schicht aus Tantalpentoxid das Aufstäuben einer Tantalpentoxidschiicht ist.
 5. Verfahren nach Anspruch 1, wobei die Metallfolienschiicht eine nickelhaltige Legierung ist.
 6. Verfahren nach Anspruch 1, wobei die Metallfolienschiicht eine chromhaltige Legierung ist.
 7. Verfahren nach Anspruch 1, wobei die Metallfolienschiicht eine Nickel-Chrom-Legierung ist.
 8. Dünnschicht-Chipwiderstand (20), der mit dem Verfahren nach Anspruch 1 hergestellt werden kann und Folgendes umfasst: ein Substrat (12); eine ohmsche dünne Metallfolienschiicht (14), die direkt auf dem Substrat befestigt wird, einen Chipwiderstandsabschluss (18), der an jedem Ende der ohmschen dünnen Metallfolienschiicht (14) befestigt wird; und eine äußere Feuchtigkeitsbarriere (22), die im Wesentlichen aus Tantalpentoxid besteht, das direkt auf die ohmsche dünne Metallfolienschiicht (14) aufgebracht und daran befestigt wird, um Ausfälle aufgrund von elektrolytischer Korrosion bei Stromzufuhr unter feuchten Bedingungen zu reduzieren, wobei das Tantalpentoxid nicht durch natürliche Oxidation der ohmschen dünnen Metallfolienschiicht gebildet wird.
 9. Dünnschicht-Chipwiderstand (20) nach Anspruch 8, wobei die ohmsche dünne Metallfolienschiicht (14) eine nickelhaltige Legierung ist.
 10. Dünnschicht-Chipwiderstand (20) nach Anspruch 8, wobei die ohmsche dünne Metallfolienschiicht (14) eine chromhaltige Legierung ist.
 11. Dünnschicht-Chipwiderstand (20) nach Anspruch 8, wobei die ohmsche dünne Metallfolienschiicht (14) eine Nickel-Chrom-Legierung ist.
 12. Dünnschicht-Chipwiderstand (20) nach Anspruch 8, wobei das Tantalpentoxid durch Aufstäuben aufgelegt wird.
 13. Dünnschicht-Chipwiderstand (20), der mit dem Verfahren nach Anspruch 1 hergestellt werden kann und Folgendes umfasst: ein ohmsches Substrat (12); eine ohmsche dünne Metallfolienschiicht (14), die direkt an dem Substrat (12) befestigt wird, wobei die dünne Metallschiicht kein Tantal ist; einen Chipwiderstandsabschluss (18), der an jedem Ende der ohmschen dünnen Metallfolienschiicht (14) befestigt wird; eine Passivierungsschiicht (16), die direkt auf der ohmschen dünnen Metallfolienschiicht (14) liegt; eine äußere Feuchtigkeitsbarriere (22), die aus Tantalpentoxid besteht, das direkt auf der Passivierungsschiicht (16) liegt, um Ausfälle aufgrund von elektrolytischer Korrosion bei Stromzufuhr unter feuchten Bedingungen zu reduzieren, wobei die Tantalpentoxidschiicht nicht natürlich durch Oxidation gebildet wird.

Revendications

1. Procédé de fabrication d'une résistance pastille à couche mince avec une barrière de pentoxyde de tantale contre l'humidité, comprenant : le dépôt d'une couche résistive à pellicule métallique qui est superposée directement à un substrat de résistance pastille à couche mince et s'y attache ; la fixation d'une terminaison de résistance pastille sur chaque extrémité de la couche résistive à pellicule métallique ; et le dépôt de la barrière contre l'humidité, qui se compose essentiellement d'une couche à pellicule de pentoxyde de tantale et qui recouvre la couche résistive à pellicule métallique dans le but de réduire les défaillances dues à la corrosion électrolytique dans des conditions d'humidité sous tension, alors que la couche de pentoxyde de tantale n'est pas formée par une oxydation naturelle de la couche résistive à pellicule métallique mince.
2. Le procédé selon la revendication 1, et comprenant en outre l'action consistant à superposer directement et à attacher la barrière contre l'humidité à la couche résistive à pellicule.
3. Le procédé selon la revendication 1, et comprenant en outre l'action consistant à superposer directement et à attacher une couche de passivation à la

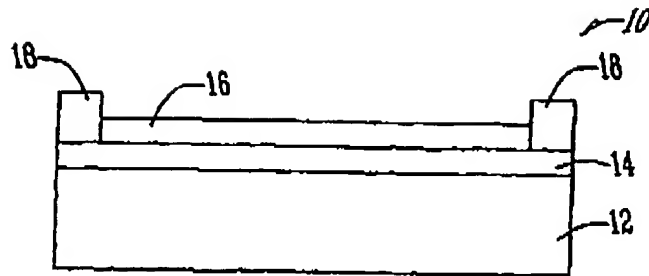
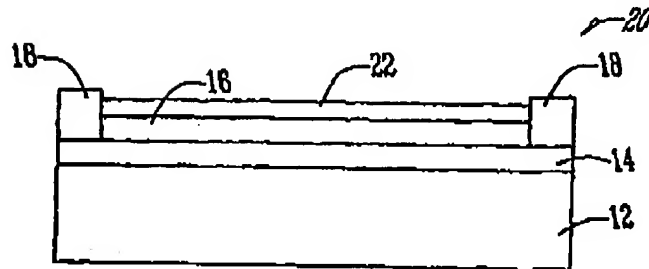
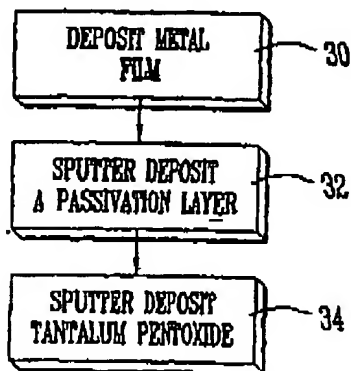
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- couche résistive à pellicule métallique ainsi que l'action consistant à superposer directement et à attacher la barrière contre l'humidité à la couche de passivation.
4. Le procédé selon la revendication 1, dans lequel l'étape de dépôt d'une couche de pentoxyde de tantale consiste à pulvériser une pellicule de pentoxyde de tantale.
 5. Le procédé selon la revendication 1, dans lequel la couche à pellicule métallique est un alliage contenant du nickel.
 6. Le procédé selon la revendication 1, dans lequel la couche à pellicule métallique est un alliage contenant du chrome.
 7. Le procédé selon la revendication 1, dans lequel la couche à pellicule métallique est un alliage de nickel-chrome.
 8. Résistance pastille (20) à couche mince pouvant être fabriquée par le procédé conforme à la revendication 1 comprenant : un substrat (12) ; une couche résistive à pellicule métallique mince (14) laquelle est directement attachée au substrat, une terminaison (18) de résistance pastille étant attachée sur chaque extrémité de la couche résistive à pellicule métallique mince (14) ; et une barrière externe (22) contre l'humidité essentiellement constituée de pentoxyde de tantale qui est directement superposée à la couche résistive à pellicule métallique mince (14), et qui y est attachée, afin de réduire les défaillances dues à la corrosion électrolytique se produisant sous des conditions d'humidité sous tension, alors que le pentoxyde de tantale n'est pas formé par une oxydation naturelle de la couche résistive à pellicule métallique mince.
 9. La résistance pastille (20) à couche mince de la revendication 8, dans laquelle la couche résistive à pellicule métallique mince (14) est un alliage contenant du nickel.
 10. La résistance pastille (20) à couche mince de la revendication 8, dans laquelle la couche résistive à pellicule métallique mince (14) est un alliage contenant du chrome.
 11. La résistance pastille (20) à couche mince de la revendication 8, dans laquelle la couche résistive à pellicule métallique mince (14) est un alliage contenant du nickel-chrome.
 12. La résistance pastille (20) à couche mince de la revendication 8, dans laquelle le pentoxyde de tantale est superposé par pulvérisation.
 13. Résistance pastille (20) à couche mince pouvant être fabriquée conformément au procédé de la revendication 1 comprenant : un substrat résistif (12) ; une couche résistive à pellicule métallique mince (14) laquelle est directement attachée au substrat (12), la pellicule métallique mince n'étant pas du tantale ; une terminaison (18) de résistance pastille, laquelle est attachée sur chaque extrémité de la couche résistive à pellicule métallique mince (14) ; une couche de passivation (16), laquelle est directement superposée à la couche résistive à pellicule métallique mince (14) ; une barrière externe (22) contre l'humidité constituée de pentoxyde de tantale qui est directement superposée à la couche de passivation (16) afin de réduire les défaillances dues à la corrosion électrolytique se produisant sous des conditions d'humidité sous tension, alors que la couche de pentoxyde de tantale n'est pas formée naturellement par oxydation.

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*Fig. 1 (PRIOR ART)**Fig. 2**Fig. 3*